

# INNER SHELF MOLLUSCA OF THE BAY OF ISLANDS, NEW ZEALAND, AND THEIR DEPTH DISTRIBUTION

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*Abstract.* The Bay of Islands on the east coast of Northland, has the most diverse molluscan fauna of any area of similar size in New Zealand. We record 551 mollusc species (389 gastropods, 139 bivalves, 20 chitons, 2 scaphopods and 1 shelled cephalopod) from intertidal to 60 m depths, estuarine to exposed oceanic, rocky shores to muddy seafloor. The high diversity is a result of the wide range of habitats present and the area's location within the warm waters of the Aupourian Province (east coast of the northern North Island). Indeed 192 Bay of Islands species appear to be largely restricted in New Zealand to this province. At least three subtropical gastropods (*Terebra circumcincta*, *Phenacovolva wakayamaensis*, *Natica lemniscata*) have arrived naturally, established small populations, and then after several years apparently died out in the Bay of Islands. Four bivalves (*Crassostrea gigas*, *Limaria orientalis*, *Musculista senhousia*, *Theora lubrica*) and one gastropod (*Microtralia occidentalis*) are believed to be exotic species introduced by shipping. The depth ranges of live molluscan specimens and their dead shells, together with those of other hard-shelled invertebrates, have been compiled from 330 dredge samples from throughout the Bay, supplemented by numerous intertidal and snorkel surveys around shallow rocky areas.

KEYWORDS: Mollusca; New Zealand; Bay of Islands; biogeography.

## INTRODUCTION

Most of the shallow water, inner shelf (0-50 m depth), molluscs of mainland New Zealand are now described (Powell 1979; Spencer and Willan 1996) and their broad biogeographic distribution patterns around the country are moderately well understood (e.g. Powell 1955, 1979; Spencer and Willan 1996), but their ecological distribution is poorly documented, except for those living in intertidal habitats (e.g. Morton and Miller 1968). The most simplistic variable used in describing the ecological distribution of subtidal molluscs is their depth range, but even this is poorly recorded.

The depth ranges of modern molluscs is particularly useful in paleoenvironmental interpretations of fossil assemblages (e.g. Beu and Maxwell 1990, Eagle *et al.* 1995). This depth data is currently not easy to find, with one of the main sources still being the observations 60 years ago in the Waitemata Harbour by Powell (1937). An offshoot of our extensive dredge surveying of the seafloor biota of the Bay of Islands (unpub.) is the generation of a major data set on the depth distribution of hundreds of mollusc species and other hard-shelled marine invertebrate remains.

In Appendix 1 we present the depth ranges of both the live and dead shells. We recognise that the dead shells are in some places subject to post-mortem transport by strong bottom

currents or storm waves but this is not so widespread as to homogenise or hide the original depth distribution patterns. Large-scale post-mortem transport occurs in the Bay of Islands only in the shallows (c. 0-5 m) along exposed shores and in narrow, current-swept channels. In many instances it results in the abrasion of heavy shells and loss of more fragile ones. Presenting both the recorded live and dead range of shells is particularly useful for paleoecological studies that will be based upon them. For rarer species for which we have recorded few if any living specimens (e.g. *Anisodonta alata*, *Austrofusus glans*, *Myllita stowei*), the dead range often supplies a good indication of the possible live depth ranges. For more abundant species which have a dead range far exceeding the recorded living range (e.g., *Crepidula costata*, *Chlamys zelandiae*, *Myadora striata*, *Tucetona laticostata*), it may be suggesting that the species lives in high energy environments where the shells are often transported away after death. If the dead range of an abundant species is very similar to the living range (e.g., *Epitonium minora*, *Moerella huttoni*, *Nucula hartvigiana*), it may be that the species is living in quieter, finer sediment habitats where the shells are seldom swept away. Similar patterns can be expected in the fossil record.

Previous documentation of the ecological distribution of some molluscs in the Bay of Islands is contained in a study of the soft bottom biota in the shallows around Urupukapuka Island (Hayward *et al.* 1981) and this has been incorporated into this study.

## STUDY AREA

The area covered by this report is the greater Bay of Islands (ca. 35°15'S, 174°12'E), encompassing everything landward of a line joining Cape Brett and Piercy Island in the east to Ninepin Island and Purerua Peninsula in the north (Fig. 1). The only substantial part of the Bay of Islands not surveyed was the upper part of the Kerikeri Arm in the north-west. The Bay of Islands is a drowned river valley with tributaries, which has resulted in many small embayments, islands and estuaries. Depths range from 50-60 m in the exposed open mouth of the bay to intertidal, mangrove-fringed mud flats around the head of many of its arms. Substrates range from hard greywacke and basalt shorelines through coarse subtidal shell or rhodolith gravels and clean sands to soft intertidal mud and muddy fine sand in the deeper parts.

## METHODS

The data on molluscan occurrence and distribution summarised in this paper has been assembled from a combination of dredge samples, shallow subtidal snorkel surveys and intense intertidal surveys undertaken during six weeks of field work by the Auckland Museum Marine Department from 1992 to 1997. We took 330 dredge samples from subtidal depths, 0-60 m below sea level, using a 10 litre capacity rectangular bucket dredge that generally penetrated 5-10 cm into the seafloor sediment, depending on its hardness. The snorkel and intertidal surveys mostly targeted rocky habitats, but included beaches, to supplement the dredge data on the soft substrate fauna. These latter surveys included micromollusc searches in sediment samples from under rocks, seaweed washes and rock washes.

Sediment retrieved by dredging was passed through a sieve with 1 mm openings and all live molluscs retained were identified and counted. A complete species list of dead shells with a qualitative assessment of abundance was also prepared from the sediment residue from each dredge station. For the purposes of this report, the quantitative data on live molluscs has also been converted to a qualitative assessment of abundance. During each snorkel and intertidal survey a molluscan species list with a similar qualitative assessment of abundance of live and dead specimens was compiled. All these results have been combined and are presented in qualitative abundance classes at 5-20 metre depth intervals in Appendix 1.

Voucher specimens of each species are lodged in the collections of the Auckland War



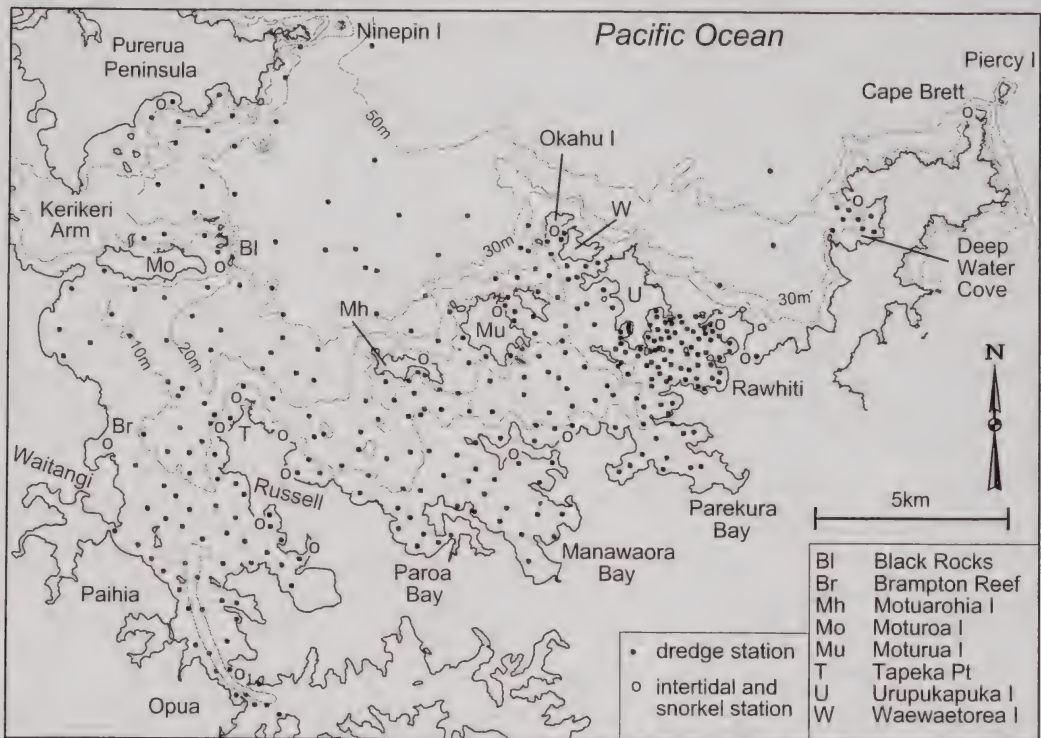


Fig. 1. Bay of Islands, showing location of the 330 dredge stations and numerous intertidal and shallow subtidal snorkel surveys upon which most of the depth ranges in this paper are based.

Memorial Museum, and registration numbers are given where appropriate (e.g., AK130909 for *Terebra circumcincta*).

### SPECIES DIVERSITY AND BIOGEOGRAPHY

We record 551 mollusc species from the Bay of Islands (Appendix 1). This can be compared with the number of species recorded through extensive studies of three smaller areas also on the northeast coast of the North Island: 351 species from sand dredged from 40 m depth off Pakiri (Morley, Goulstone *et al.* 1997); 340 species from Oneroa Bay, Waiheke Island (Morley unpub.); and 167 species recorded from the central and upper Waitemata Harbour (Hayward *et al.* 1999). All three areas have a narrower range of habitats and are smaller than the Bay of Islands and this contributes to their lower species diversity.

Lower levels of molluscan diversity have also been recorded from large areas on the west coast of the North Island—192 species from around Kawerua, west Northland (Hayward *et al.* 1995); 192 species from Kawhia area (Morley, Hayward *et al.* 1997); and 197 species from the coast of northern Taranaki (Hayward *et al.* in press).

Still further south, in an area of similar size and habitat diversity to the Bay of Islands, 367 molluscs (not including soft-bodied cephalopods) have been recorded from Wellington Harbour and its approaches (Marshall 1998). The Wellington records include 19 chitons, 231 gastropods and 114 bivalves, which compare with 20, 389 and 139 respectively from the Bay of Islands.

There are 249 species (12 chitons, 153 gastropods, 82 bivalves) common to both Wellington and the Bay of Islands. Thus a far greater percentage of gastropods appear to prefer the warmer waters of the Bay of Islands, than any of the other mollusc classes.

The Bay of Islands probably has the highest diversity of shallow-water molluscs for any area of this size in New Zealand. There are several reasons for this high diversity:

1. The location on the north-east coast of Northland within the warm-water Aupourian Province—the New Zealand biogeographic province with the highest diversity of molluscs.
2. The area extends from marginally oceanic conditions on the fringe of the eddies of the warm East Auckland Current, to shallow water neritic and brackish conditions.
3. There is a wide range of habitats from sheltered, muddy estuarine to exposed, marginally oceanic, rocky shore. The only major nearshore habitats that are largely lacking are rocky shores soft enough for rock borers, and exposed oceanic beaches for surf clams.
4. The water quality is generally high and little impacted by human-induced pollution and increased sedimentation.

#### SUBTROPICAL VISITORS (Fig. 2)

The warm waters of the south-flowing East Auckland Current periodically introduce tropical or subtropical molluscs and other marine biota to the east coast of Northland (e.g. Powell 1976). Most of these have been recorded from localities, like the Poor Knights Islands, which are more in the path of the current, but eddies sometimes impinge on Cape Brett peninsula at

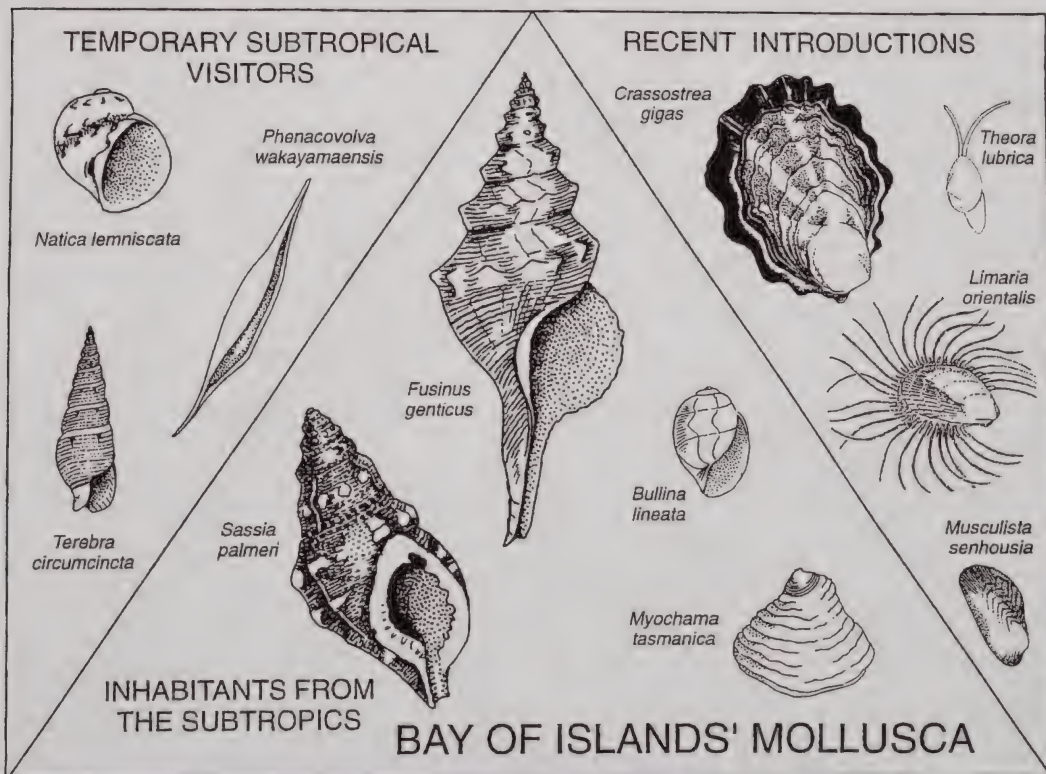


Fig. 2. Examples of subtropical and introduced molluscs recorded from the Bay of Islands.



the entrance to the Bay of Islands, and have introduced a few warm-water species.

Three such species that have been introduced to the Bay of Islands by warm currents, and that bred for a season or two and established small populations, now appear to have died out. These are:

1. *TEREBRA CIRCUMCINCTA*. A small population (AK130909) was found living in the warm subtidal shallows of Waewaetorea Channel in the 1970s and early 1980s (Powell 1979), but it could not be found at this locality alive or dead in the mid 1990s.
2. *PHENACOVOLVA WAKAYAMAENSIS*. A small population was living on gorgonians off Cape Brett Peninsula in the early 1990s, but had disappeared a few years later (Fred. Brook pers. comm.). It has also been recorded from the Poor Knights Islands (Powell 1979).
3. *NATICA LEMNISCATA*. Three specimens were washed up on the beach at Urupukapuka Island and recorded by Powell (1979, as *N. sagittata hancockae*); and one was found by us on Okahu Island (AK89611) in 1994. Shells have also been found at the Poor Knights Islands and Cape Karikari (Fred Brook pers. comm.).

The Bay of Islands species list includes a group of subtropical taxa, largely restricted to, and rare within, the Aupourian Province:

1. *ACTEON CRATICULATUS* and *A. MILLERI*. Dredged from 21 and 38 m depth off Moturua Island near the middle of the Bay of Islands (AK100859, 102006). Elsewhere in New Zealand *A. craticulatus* has been sporadically recorded off the east coast of the northern North Island as far south as Gisborne (Auckland War Memorial Museum collections), and *A. milleri* has been recorded from off Pakiri (Morley, Goulstone *et al.* 1997).
2. *BULLA ANGASI*. Found washed up on Motuarohia Island (AK133208) and dead at 10 m depth (this study). Elsewhere in New Zealand recorded in beach wash-ups between Cape Maria van Diemen and Whangarei (Powell 1979).
3. *BULLINA LINEATA*. Dredged from 38 m depth near the centre of the open mouth of the Bay of Islands (AK131267) and seen alive at 6 m depth off Urupukapuka Island during a SCUBA dive in 1985 (Steve O'Shea pers. comm.). There are sporadic records down the east coast of Northland to the Bay of Plenty (Powell 1979, Morley, Goulstone *et al.* 1997).
4. *CASMARIA PERRYI*. Observed live at 5 m depth off Cape Brett Peninsula in 1991 (Fred Brook, pers. comm.). Also known in New Zealand from Great Barrier Island (Powell 1979).
5. *FUSINUS GENTICUS*. One live specimen (AK139772) was collected by Kevin Burch at 30 m depth in Deep Water Cove during a SCUBA dive in 1998. Elsewhere recorded sporadically off the east coast of northern Northland (Morley unpub.).
6. *NASSARIUS SPIRATUS*. Found washed up on Okahu Island (AK131231) and in a dredge haul from Deep Water Cove. There are other rare records along the east coast of Northland from North Cape to Great Barrier Island (Powell 1979, Morley unpub.).
7. *NATICA MIGRATORIA*. Found washed up on Okahu Island (AK89610). Elsewhere in New Zealand recorded from Parengarenga Harbour and a few scattered localities down the east coast of Northland and Coromandel (Powell 1979, Morley unpub.).
8. *POLINICES SIMIAE*. Found washed up at Tapeka Point (Powell 1979) and on Motuarohia Island (AK133218, this study). Elsewhere in New Zealand recorded dead from a few localities down the east coast of Northland and the Bay of Plenty (Powell 1979).
9. *NOVASTOA LAMELLOSA*. This colonial vermetid gastropod lives attached to low tidal basalt on the Black Rocks in the Bay of Islands (AK149002). Elsewhere it occurs at the Moturoa, Poor Knights, Great Mercury, White and Chatham Islands (Grace and Puch 1977, Powell 1979).
10. *POLINICES TAWHITIRAHIA*. Recorded from shallow water in the Bay of Islands (Powell 1979). Not found during this survey, but observed at 10 m depth off Cape Brett Peninsula in 1994 (Fred Brook, pers. comm.). Elsewhere in New Zealand recorded from the Cavalli and

Poor Knights Islands (Powell 1979).

11. *SASSIA PALMERI*. Found dead at 18 m depth off Cape Brett Peninsula (Fred Brook, pers. comm.). Elsewhere in New Zealand recorded from the Poor Knights Islands and off Pakiri (Powell 1979, Morley, Goulstone *et al.* 1997).

12. *SASSIA PARKINSONIA*. Recorded living in Deep Water Cove (AK75044) and washed up on Okahu Island (AK90122) in the Bay of Islands in 1981 (Morley unpub.). Elsewhere recorded sporadically along the east coast of Northland and Bay of Plenty (Powell 1979).

13. *SEMICASSIS ROYANUM*. Seen live at 25 m off Cape Brett Peninsula in 1992 (Fred Brook, pers. comm.). Elsewhere in New Zealand observed live at the Poor Knights Islands (Powell 1979).

14. *TUTUFA BUFO*. Dead shell collected by Steve O'Shea during a SCUBA dive off Moturoa Island in 1984 (Morley unpub.) and live juveniles seen by Fred Brook at 20 m depth off Cape Brett Peninsula in 1994. Elsewhere in New Zealand recorded from Spirits Bay, Parengarenga Harbour, Doubtless Bay and the Poor Knights Islands (Powell 1979).

15. *MYOCHAMA TASMANICA*. Dredged from the middle of the entrance to the Bay of Islands in 38 and 44 m water depth (AK100851). Elsewhere in New Zealand recorded only from Parengarenga Harbour (Powell 1979), where it occurs in shallower depths.

Not recorded here from the Bay of Islands, however, are a number of other subtropical "visitors" that have arrived naturally off Northland's east coast in recent decades e.g. *Aglaja lineolata*, *Conus lischkeanus kermadecensis*, *Epitonium lamellosa*, *Hydatina albocincta*, *Neothais clathrata*, *Semicassis sophia*, *Tonna cumingii*, *T. maculata* (e.g., Powell 1976).

#### WARM-WATER AUPOURIAN-RESTRICTED SPECIES

In addition to the subtropical species mentioned above, many other mollusc species living in the Bay of Islands have a New Zealand distribution limited to the warm waters of the Aupourian Province. Indeed, 35% (192 species) of the Bay of Islands' molluscs are restricted to the Aupourian Province. These are dominantly gastropods (163 species), with fewer Aupourian-restricted bivalves (28 species) and chitons (1 species).

#### INTRODUCED EXOTIC SPECIES (Fig. 2)

Four of the bivalves recorded here from the Bay of Islands have been introduced to New Zealand within the last three decades and are now widespread along the north-east coast of the North Island and have had a major impact on the biota of the Waitemata Harbour, Auckland (Hayward *et al.* 1997, Hayward 1997). These are the Pacific oyster (*Crassostrea gigas*) which lives in great abundance on intertidal rocks and in several oyster farms in the Bay of Islands; the Asian mussel (*Musculista senhousia*) which lives in small transient thickets in Otehei (Urupukapuka Island), Parekura, Manawaora and adjacent bays; the small Asian semele (*Theora lubrica*) which lives in large numbers in shallow muddy sediments throughout most of the bay; and the file shell (*Limaria orientalis*) which is widespread in the subtidal shallows in many parts of the Bay of Islands.

The gastropod *Microtralia occidentalis*, present in the Bay of Islands, has probably also been introduced to New Zealand by humans (Climo 1982). It lives around high tide mark and also occurs around the fringes of the Waitemata Harbour (Hayward 1997, Hayward *et al.* 1999).

#### DEPTH RANGES

Bay of Islands depth ranges are given in Appendix 1. We have not searched the literature to determine the total known depth range of taxa that also live deeper than 60 m outside the study area. The subtidal ranges are based almost exclusively on soft substrate dredge records



and thus the depth ranges of harder substrate inhabitants are under-reported.

Although this study is limited to intertidal and inner shelf depths (0-60 m), there are many taxa that are restricted to only part of this depth range. Here we have grouped together the more abundant or characteristic taxa of these restricted depth zones, citing total depth range, followed by live depth range in italics.

### INTERTIDALLY-RESTRICTED, ON ROCKS AND SEAWEED (Fig. 3)

Chiton: *Sypharochiton pelliserpentis*.

Gastropods: *Diloma* spp., *Haustrum haustorium*, *Lepsiella scobina*, *Melagraphia aethiops*, *Micrelenchus tenebrosus*, *Nerita atramentosa*, *Nodilittorina antipodum*, *N. cincta*, *Notoacmea helmsi*, *N. parviconoidea*, *N. pileopsis*, *Novastoa lamellosa*, *Onchidella nigricans*, *Patelloida corticata*, *Risellopsis varia*, *Siphonaria australis*, *Zeacumantus subcarinatus*.

Bivalves: *Crassostrea gigas*, *Saccostrea cucullata*, *Xenostrobus pulex*.

Barnacles: *Chamaesipho brunnea*, *C. columna*, *Epopella plicata*, *Elminius modestus*.



Fig. 3. Schematic diagram showing a selection of more common or characteristic molluscs of various habitats and depths in the Bay of Islands. Several illustrations are from Powell (1947).

## INTERTIDALLY-RESTRICTED, ON SOFT SUBSTRATES

Gastropods: *Amphibola crenata*, *Diloma subrostrata* (on shells or stones), *Potamopyrgus estuarinus*, *Zeacumantus lutulentus*.

## INTERTIDAL AND SHALLOW SUBTIDAL (Fig. 3)

Chitons: *Acanthochitona zelandica* (0-8 m, 0-8 m), *Chiton glaucus* (0-5 m, 0-2 m), *Ischnochiton maorianus* (0-14 m, 0-14 m).

Gastropods: *Amalda novaezelandiae* (0-44 m, 0-40 m), *Bulla quoyii* (0-12 m, 0-7 m), *Cantharidus purpureus* (0-31 m, 0-5 m), *Cellana stellifera* (0-11 m, 0-2 m), *Cominella adpersa* (0-18 m, 0-18 m), *Cominella quoyana* (0-32 m, 0-32 m), *Neoguraleus murdochi* (0-29 m, 0-5 m), *N. lyallensis* (0-31 m, 0-6 m), *Pervicacia tristis* (0-22 m, 0-12 m), *Rissoina chathamensis* (0-16 m, 3-16 m), *Turbo smaragdus* (0-44 m, 0-3 m).

Bivalves: *Austrovenus stutchburyi* (0-20 m, intertidal), *Macomona liliiana* (0-16 m, 0-7 m), *Musculista senhousia* (0-5 m, 0-5 m), *Nucula hartvigiana* (0-25 m, 0-17 m), *Ruditapes largillierti* (0-32 m, 0-8 m), *Theora lubrica* (0-55 m, 0-27 m).

Echinoid: *Evechinus chloroticus* (0-5 m+, 0-5 m+).

## DOMINANTLY SUBTIDAL

Chitons: *Leptochiton inquinatus* (0-34 m, 0-34 m), *Rhysoplax stangeri* (1-21 m, 1-21 m).

Gastropods: *Antisolarium egenum* (2-38 m, 7-24 m), *Epitonium minor* (1-40 m, 1-38 m), *Epitonium tenellum* (0-7 m, 3-5 m), *Maoricolpus roseus* (0-32 m, 0-13 m), *Micrelenchus rufozonus* (2-34 m, 2-27 m), *Pupa kirki* (1-55 m, 1-55 m), *Sigapatella novaezelandiae* (0-55 m, 0-55 m), *Sinuginella pygmaea* (0-55 m, 1-31 m), *Xymene plebeius* (0-28 m, 0-21 m), *Zeacolpus pagoda* (1-42 m, 1-29 m), *Zegalerus tenuis* (0-44 m, 1-22 m).

Bivalves: *Aribritica bifurca* (2-38 m, 2-38 m), *Atrina zelandica* (1-42 m, 3-38 m), *Chlamys zelandica* (0-55 m, 2-6 m), *Corbula zelandica* (0-44 m, 0-32 m), *Dosina zelandica* (0-38 m, 1-32 m), *Dosinia maoriana* (3-38 m, 3-31 m), *Dosinia subrosea* (1-15 m, 1-13 m), *Felaniella zelandica* (0-55 m, 0-29 m), *Gari convexa* (2-7 m, 2-7 m), *Gari lineolata* (1-38 m, 1-22 m), *Gari stangeri* (1-31 m, 1-15 m), *Glycymeris modesta* (1-40 m, 2-27 m), *Hunkydora australica novozelandica* (0-44 m, 2-32 m), *Leionucula strangei* (6-35 m, 6-35 m), *Leptomys retiararia* (0-34 m, 0-20 m), *Limatula maoria* (2-44 m, 2-14 m), *Melliteryx parva* (2-44 m, 2-12 m), *Moerella buttoni* (2-38 m, 2-29 m), *Myadora striata* (0-32 m, 1-18 m), *Notocallista multistriata* (0-44 m, 0-44 m), *Nucula nitidula* (0-44 m, 0-29 m), *Pecten novaezealandiae* (0-44 m, 3-38 m), *Pleuromeris zelandica* (0-48 m, 0-29 m), *Scalpomactra scalpellum* (1-44 m, 1-29 m), *Talabrica bellula* (2-34 m, 2-32 m), *Tawera spissa* (0-44 m, 1-30 m), *Tellinota edgari* (0-20 m, 1-20 m), *Tucetona laticostata* (0-38 m, 2-21 m), *Venericardia purpurata* (0-55 m, 2-34 m), *Zenatia acinaces* (0-38 m, 0-38 m).

Echinoid: *Echinocardium cordatum* (0-35 m, 4-35 m).

Corals: *Culicia rubeola* (1-55 m, 1-15 m), *Monomyces rubrum* (0-31 m, 0-31 m).

Rhodolith alga: (0-30 m, 2-11 m).

## RESTRICTED TO DEEPER WATER (Fig. 3)

Gastropods: *Liracraea odhneri* (>18 m, none live), *Microvoluta marginata* (8-40 m, 8-38 m), *Poirieria zelandica* (>13 m, none live), *Rhizorus nesentus* (4-40 m, 28-38 m).

Bivalves: *Anisodonta alata* (>11 m, none live), *Crenella radians* (>31 m, none live), *Cuspidaria trailli* (>20 m, >38 m), *Neilo australis* (>11 m, >15 m), *Pratulium pulchellum* (2-44 m, 15-44 m), *Saccella bellula* (7-55 m, 27-48 m), *Serratina charlottae* (>13 m, >13 m).



Scaphopods: *Antalis nana* (>16 m, >17 m), *Cadulus teliger* (>21 m, none live).  
Corals: *Kionotrochus suteri* (>38 m, none live), *Sphenotrochus ralphae* (>10 m, >27 m).

## TAXONOMIC NOTES

### *Subspecies of Liratilia conquista* (Suter, 1907)

Powell (1979) and Spencer and Willan (1996) recognise a northern subspecies (*L. c. conquista*) and a southern subspecies *L. conquista angulata* (Suter, 1908). The latter is distinguished by its more angulated whorls resulting from the differing strengths of spiral cords. In a dredge sample from 7 m off Motuarohia Island in the Bay of Islands there are shells identical in character to both these subspecies (AK93678, 93688). Forms identifiable as both subspecies are also present in a sample from 92 m off the Three Kings Islands (AK19151). We conclude that these two morphotypes are not geographically separate subspecies and at most should be considered separate forms.

### *Subspecies of Neoguraleus lyallensis* (Murdoch, 1905)

Powell (1979) and Spencer and Willan (1996) recognise a southern nominate subspecies (*N. l. lyallensis*) and a northern subspecies *N. lyallensis tenebrosus* (Powell, 1926). The latter is distinguished by being more broadly ovate, less ornamented and having a dark, leaden grey colour compared with a yellowish-brown colour of the nominate subspecies. Study of shell populations from the Bay of Islands and elsewhere in northern New Zealand (e.g. AK84599, 100725) shows that shape, extent of axials and colour is highly variable within populations, with specimens referable to both subspecies present together. We suspect that some of the lighter-coloured nominate subspecies are faded leaden grey *N. l. tenebrosus*. We conclude that these two morphotypes are not geographically separate subspecies and at most should be considered separate forms, and thus we would refer to all as *N. lyallensis*.

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APPENDIX 1. Species list, depth ranges and qualitative assessment of abundance of molluscs from the Bay of Islands compiled from subtidal dredge, snorkel, and intertidal surveys with additional records of rarer species supplied by colleagues, shell collectors and records of Auckland War Memorial Museum holdings. This list does not include unshelled cephalopods. Also listed are some other marine invertebrates and rhodoliths (calcareous red algae) that have hard shell remains (e.g. barnacles, echinoids, corals and brachiopods), as their depth ranges are also of potential value to paleoecologists. Taxonomy follows Spencer and Willan (1996) with a few modifications (*Atrina*, *Herpetopoma*, *Scutus*) following Marshall (1998 and pers. comm.). Qualitative measures of abundance within depth ranges: a = living, A = living (averaging >1 per 50 litres of total sediment sampled), d = dead, D = dead (averaging >1 per 50 litres of total sediment sampled), (a) or (d) = observed living or dead during a scuba or snorkel dive, 1970s-1990s, x = collected previously from the Bay of Islands, depth not recorded.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
Number of stations	8	78	59	32	18	9	9	11	5
POLYPLACOPHORA									
<i>Acanthochitona rubiginosa</i>	.	.	a	.	.	.	.	.	.
<i>Acanthochitona violacea</i>	a	a	d	.	.	.	.	.	.
<i>Acanthochitona zelandica</i>	A	A	A	.	.	.	.	.	.
<i>Callochiton</i> aff. <i>oligosulcatus</i>	a	.	.	.	.	.	.	.	.
<i>Chiton glaucus</i>	A	a	.	.	.	.	.	.	.
<i>Cryptoconchus porosus</i>	a	.	.	.	.	.	.	.	.
<i>Eudoxochiton nobilis</i>	a	.	.	.	.	.	.	.	.
<i>Ischnochiton luteoroseus</i>	.	a	.	.	.	.	.	.	.
<i>Ischnochiton maorianus</i>	A	A	a	a	.	.	.	.	.
<i>Ischnochiton</i> aff. <i>maorianus</i>	x	.	.	.	.	.	.	.	.
<i>Leptochiton inquinatus</i>	A	A	A	A	a	a	a	a	.
<i>Leptochiton</i> sp.	.	.	a	.	.	.	.	.	.
<i>Lorica haurakiensis</i>	.	.	a	.	.	.	.	.	.
<i>Onithochiton neglectus</i>	a	a	a	.	a	.	.	.	.
<i>Plaxiphora obtecta</i>	a	.	.	.	.	.	.	.	.
<i>Pseudotonicia cuneata</i>	.	a	A	.	.	.	.	.	.
<i>Rhyssoplax canaliculata</i>	.	.	a	.	.	.	.	.	.
<i>Rhyssoplax stangeri</i>	.	A	A	a	.	a	.	.	.
<i>Rhyssoplax</i> sp.	x	.	.	.	.	.	.	.	.
<i>Sypharochiton pelliserpentis</i>	A	d	a	.	.	.	.	.	.
GASTROPODA									
<i>Acteon craticulatus</i>	.	.	.	.	.	.	.	d	.
<i>Acteon milleri</i>	.	.	.	.	.	.	.	a	.
<i>Adelphotectonica reevei</i>	.	.	.	.	.	.	.	a	.
<i>Agatha georgiana</i>	.	D	d	d	.	d	.	d	d
<i>Alcithoe arabica</i>	.	d	.	.	.	.	.	.	d
<i>Alcithoe haurakiensis</i>	.	.	.	.	.	.	.	.	d
<i>Alipta crenistria</i>	.	.	.	d	.	.	.	.	.
<i>Alloiodoris lanuginata</i>	x	.	.	.	.	.	.	.	.
<i>Alvania pingue</i>	.	.	.	.	.	.	.	.	a
<i>Alvania pinguoides</i>	x	.	.	.	.	.	.	.	.
<i>Amalda australis</i>	d	a	a	a	d	.	.	d	.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
<i>Amalda mucronata</i>	.	d	d	d	d	.	a	d	.
<i>Amalda northlandica</i>	.	.	.	d	.	.	.	.	.
<i>Amalda novaezelandiae</i>	A	A	A	A	A	A	A	A	d
<i>Amphibola crenata</i>	a	d	d	.	d	.	.	.	.
<i>Amphithalamus falsestea</i>	.	d	d	d	.	.	.	.	.
<i>Amphithalamus semen</i>	.	d	.	.	.	.	.	.	.
<i>Amphithalamus ornatus</i>	a	.	.	.	.	.	.	.	.
<i>Amphithalmus latisulcus</i>	.	.	.	d	.	.	.	.	.
<i>Anabathron elongatus</i>	.	.	.	d	.	.	.	.	.
<i>Anabathron excelsus</i>	.	d	.	.	.	.	.	.	.
<i>Anabathron hedleyi</i>	a	.	.	.	.	.	.	.	.
<i>Anabathron ovatus</i>	.	d	d	d	.	.	.	.	.
<i>Anabathron rugulosus</i>	x	.	.	.	.	.	.	.	.
<i>Antimelatoma buchanani maorum</i>	.	d	.	a	a	.	.	d	.
<i>Antisolarium egenum</i>	.	D	A	A	d	A	D	d	.
<i>Austrodrillia rawitiensis</i>	.	d	.	.	.	.	.	.	.
<i>Aoteatilia larochei</i>	.	.	d	d	d	.	.	.	.
<i>Aphelodoris luctuosa</i>	.	(a)	.	.	.	.	.	.	.
<i>Aplysia juliana</i>	.	(a)	.	.	.	.	.	.	.
<i>Asteracmea suteri</i>	.	a	d	.	d	d	.	.	.
<i>Astraea heliotropium</i>	.	a	d	.	.	.	.	d	.
<i>Atalacmea fragilis</i>	a	.	.	.	.	.	.	.	.
<i>Attenuata manawatawhia</i>	.	.	.	.	.	.	.	.	d
<i>Austrodiaphana manganuica</i>	.	d	.	.	.	.	.	.	.
<i>Austrodrillia secunda</i>	.	.	.	.	.	.	.	.	d
<i>Austrofusus glans</i>	d	.	d	.	.	d	.	a	d
<i>Austromitra rubiginosa</i>	.	a	d	d	d	d	d	.	d
<i>Awanuia dilatata</i>	.	d	.	.	.	.	.	.	.
<i>Babakina caprinsulensis</i>	.	.	(a)	.	.	.	.	.	.
<i>Berghia australis</i>	a	.	.	.	.	.	.	.	.
<i>Berthella ornata</i>	x	.	.	.	.	.	.	.	.
<i>Berthellina citrina</i>	.	a	.	.	.	.	.	.	.
<i>Besla vaga</i>	.	.	.	.	.	.	.	.	a
<i>Bouchettriphora pallida</i>	.	d	d	d	.	.	a	.	.
<i>Brookula indigens</i>	.	d	d	.	.	.	.	.	.
<i>Brookula polypleura</i>	.	d	d	.	.	.	.	.	.
<i>Buccinulum linea</i>	a	a	a	.	.	.	.	d	.
<i>Buccinulum pallidum powelli</i>	.	.	(a)	.	.	.	.	.	.
<i>Buccinulum robustum</i>	d	.	a	.	.	.	.	.	.
<i>Buccinulum vittatum</i>	a	d	d	.	.	.	.	.	.
<i>Bulla angasi</i>	d	.	(d)	.	.	.	.	.	.
<i>Bulla quoyii</i>	A	A	a	d	.	.	.	.	.
<i>Bullina lineata</i>	.	.	(a)	.	.	.	.	d	.
<i>Cabestana spengleri</i>	.	.	.	.	d	.	.	.	.
<i>Caecum digitulum</i>	.	d	d	.	.	.	.	.	.
<i>Calliostoma pellucidum</i>	d	.	.	.	.	.	.	.	.
<i>Calliostoma punctulatum</i>	.	.	.	d	d	.	.	d	.
<i>Calliostoma tigris</i>	.	.	.	.	.	.	d	.	.
<i>Cantharidella tessellata</i>	d	d	.	.	.	.	.	.	.
<i>Cantharidus opalus</i>	d	d	d	.	.	.	.	.	.
<i>Cantharidus purpureus</i>	a	D	D	d	d	.	.	d	.



Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
<i>Casmaria perryi</i>	.	(a)	.	.	.	.	.	.	.
<i>Cellana ornata</i>	A	.	d	.	.	d	d	.	.
<i>Cellana radians</i>	A	.	.	.	d	.	.	d	.
<i>Cellana stellifera</i>	a	(a)	.	d	.	.	.	.	.
<i>Ceratosoma amoena</i>	.	(a)	.	.	.	.	.	.	.
<i>Charonia lampas</i>	.	(a)	.	.	.	.	.	.	.
<i>Chemnitzia kingi</i>	.	a	.	.	.	.	.	.	.
<i>Chemnitzia</i> spp.	.	d	d	d	.	d	.	.	.
<i>Chromodoris aureomarginata</i>	.	(a)	.	.	.	.	.	.	.
<i>Cirsonella</i> aff. <i>paradoxa</i>	.	d	.	.	.	.	.	.	.
<i>Cirsotrema zelebori</i>	.	a	a	d	.	a	d	.	.
<i>Coluzea spiralis</i>	x	.	.	.	.	.	.	.	.
<i>Cominella adspersa</i>	A	A	A	a	a	.	.	.	.
<i>Cominella glandiformis</i>	d	D	d	.	.	.	.	.	.
<i>Cominella maculosa</i>	a	A	.	a	.	.	.	.	.
<i>Cominella quoyana</i>	A	A	A	A	A	a	d	a	.
<i>Cominella virgata</i>	a	a	d	.	.	.	.	.	.
<i>Cookia sulcata</i>	a	a	a	.	.	.	d	.	.
<i>Crassitoniella carinata</i>	.	.	d	d	.	.	.	.	.
<i>Crepidula costata</i>	A	D	D	D	D	D	D	D	d
<i>Crepidula monoxylya</i>	A	a	d	.	.	d	.	.	.
<i>Crepidula profunda</i>	.	(a)	.	.	.	.	.	.	.
<i>Crosseola cuvieriana</i>	.	d	.	.	.	.	.	.	.
<i>Crosseola vesca</i>	.	d	d	.	.	.	.	.	.
<i>Cumia reticulata</i>	.	.	.	(a)	.	.	.	.	.
<i>Curveulima aupaouria</i>	a	.	.	.	.	.	.	.	.
<i>Cylichna thetidis</i>	.	d	a	d	a	a	a	a	d
<i>Cylichnina opima</i>	.	.	.	.	.	.	.	.	d
<i>Cymatium exaratum exaratum</i>	.	(a)	.	.	.	.	.	.	.
<i>Cymatium parthenopeum</i>	.	a	.	.	.	.	.	.	.
<i>Daphnella cancellata</i>	.	d	d	D	d	.	.	.	d
<i>Dendrodoris denisoni</i>	.	(a)	.	.	.	.	.	.	.
<i>Dermatobranchus pulcherrimus</i>	.	a	.	a	.	.	.	.	.
<i>Dicathais orbita</i>	a	d	.	.	.	.	.	d	.
<i>Dicavolinia longirostris</i>	.	.	.	.	.	.	.	d	.
<i>Diloma arida</i>	d	d	.	.	.	.	.	.	.
<i>Diloma bicanaliculata</i>	a	d	.	.	.	.	.	.	.
<i>Diloma coracina</i>	a	d	.	.	.	.	.	.	.
<i>Diloma nigerrima</i>	d	d	.	.	.	.	.	.	.
<i>Diloma subrostrata</i>	A	D	d	.	d	.	.	.	.
<i>Diloma zelandica</i>	d	d	.	.	.	.	.	.	.
<i>Dolabrifera brazieri</i>	.	a	.	.	.	.	.	.	.
<i>Doriopsis flabellifera</i>	a	.	.	.	.	.	.	.	.
<i>Eatoniella albocolumella</i>	.	d	.	.	.	.	.	.	.
<i>Eatoniella delli</i>	.	d	.	.	.	.	.	.	.
<i>Eatoniella flammulata</i>	a	.	.	d	.	.	.	.	.
<i>Eatoniella fossa</i>	.	.	.	d	.	.	.	.	.
<i>Eatoniella limbata</i>	.	d	d	d	.	.	.	.	.
<i>Eatoniella lutea</i>	.	d	.	.	.	.	.	.	.
<i>Eatoniella mortoni</i>	.	d	.	.	.	.	.	.	.
<i>Eatoniella notalabia</i>	.	d	.	.	.	.	.	.	.





Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
<i>Limulatus reliquus</i>	.	.	(a)	.	.	d	.	.	.
<i>Linopyrga rugata</i>	.	d	d	d	.	.	.	.	.
<i>Liracraea odhneri odhneri</i>	.	.	.	.	d	.	d	d	d
<i>Liracraea</i> sp.	.	.	.	.	.	d	.	.	.
<i>Liratilia conquisita conquisita</i>	.	d	d	d	.	.	.	.	.
<i>Liratilia elegantula</i>	.	d	.	.	.	.	.	.	.
<i>Liratilia eremita</i>	.	d	.	.	.	.	.	.	.
<i>Liratilia subnodosa</i>	d	.	.	.	.	.	.	.	.
<i>Lodderena formosa</i>	.	d	d	.	.	.	.	.	.
<i>Lodderia iota</i>	.	d	.	.	.	.	.	.	.
<i>Lucrapex angustatus</i>	.	.	d	.	a	a	d	d	.
<i>Macrozafra nodicincta</i>	.	.	.	.	.	.	.	.	d
<i>Macrozafra subabnormis</i>	d	.	.	.	.	.	.	.	d
<i>Maoricolpus roseus</i>	a	A	A	A	d	.	.	d	.
<i>Marinula filholi</i>	a	.	.	.	.	.	.	.	.
<i>Melagraphia aethiops</i>	A	d	.	d	.	.	.	.	.
<i>Melanella</i> sp.	.	d	d	.	.	.	.	.	.
<i>Mendax stivria</i>	d	.	.	.	.	.	.	.	.
<i>Mendax ?trizonalis</i>	.	d	d	d	.	.	.	.	.
<i>Merelina compacta</i>	.	(d)	.	.	.	.	.	.	.
<i>Merelina coronata</i>	.	(d)	.	.	.	.	.	.	.
<i>Merelina crosseiformis</i>	.	.	d	.	.	.	.	.	.
<i>Merelina lyalliana</i>	d	.	.	.	.	.	.	.	.
<i>Merelina superba</i>	.	.	d	.	.	.	.	.	.
<i>Merelina taupoensis</i>	d	.	.	.	.	.	.	.	.
<i>Metaxia duplicarinata</i>	.	d	.	.	.	.	.	.	.
<i>Metaxia exaltata</i>	.	.	d	.	.	.	.	.	.
<i>Micrelenchus dilatatus</i>	a	.	.	.	.	.	.	.	.
<i>Micrelenchus buttonii</i>	a	.	.	.	.	.	.	.	.
<i>Micrelenchus rufozonus</i>	.	A	A	D	a	d	A	d	.
<i>Micrelenchus sanguineus</i>	.	d	d	a	.	.	.	.	.
<i>Micrelenchus tenebrosus</i>	A	D	d	d	.	.	.	.	.
<i>Microdryas striatus</i>	.	d	.	.	.	.	.	.	.
<i>Microtralia occidentalis</i>	a	.	.	.	.	.	.	.	.
<i>Microvoluta marginata</i>	.	.	a	d	.	A	.	a	.
<i>Mitra carbonaria</i>	.	(a)	.	.	.	.	.	.	.
<i>Modelia granosa</i>	.	d	d	d	.	.	.	.	.
<i>Monophorus fascelina</i>	.	.	d	.	.	.	.	.	.
<i>Morula palmeri</i>	.	.	.	.	(a)	.	.	.	.
<i>Munditia delicatula</i>	x	.	.	.	.	.	.	.	.
<i>Munditia serrata</i>	.	d	.	.	.	.	.	.	.
<i>Munditia tryphenensis</i>	.	d	d	d	.	.	.	.	d
<i>Murdochella levifoliata</i>	.	.	.	.	.	.	.	.	d
<i>Murexul mariae</i>	.	.	.	.	d	.	.	d	.
<i>Murexul octogonus</i>	d	A	a	.	d	d	.	.	.
<i>Nassarius aoteanus</i>	.	.	.	.	.	.	(d)	.	.
<i>Nassarius spiratus</i>	d	.	.	.	.	.	.	.	.
<i>Natica lemniscata</i>	d	.	.	.	.	.	.	.	.
<i>Natica migratoria</i>	d	.	.	.	.	.	.	.	.
<i>Neoguraleus amoenus</i>	.	d	D	d	d	D	d	d	d
<i>Neoguraleus</i> aff. <i>benthicola</i>	.	.	.	.	d	.	.	.	.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
<i>Neoguraleus interruptus</i>	.	d	d	d	.	.	.	.	.
<i>Neoguraleus lyallensis</i>	a	A	A	.	d	d	.	d	.
<i>Neoguraleus murdochi</i>	A	A	D	D	D	D	D	.	.
<i>Neoguraleus sinclairi</i>	.	.	.	d	.	.	.	.	.
<i>Nepotilla nitidula</i>	.	.	d	.	.	.	.	.	.
<i>Nerita atramentosa</i>	a	.	.	.	.	.	.	.	.
<i>Nodilittorina cincta</i>	a	.	.	.	.	.	.	.	.
<i>Nodilittorina antipodum</i>	A	d	.	.	.	.	.	.	.
<i>Notoacmea elongata</i>	a	d	.	d	.	.	.	.	.
<i>Notoacmea helmsi</i>	a	d	d	.	d	.	d	d	.
<i>Notoacmea parviconoidea</i>	a	.	d	.	.	.	.	d	.
<i>Notoacmea pileopsis pileopsis</i>	a	.	.	.	.	.	.	.	.
<i>Notoacmea scopulina</i>	d	.	.	.	.	.	.	.	.
<i>Notoacmea subtilis</i>	.	A	a	d	.	.	.	.	.
<i>Notocrater craticulata?</i>	.	.	.	.	.	d	.	.	.
<i>Nototriphora aupouria</i>	x	.	.	.	.	.	.	.	d
<i>Novastoa lamellosa</i>	a	d	.	.	.	.	.	.	.
<i>Nozeba emarginata</i>	.	d	d	d	.	.	.	d	.
<i>Obexomia denselirata</i>	.	d	d	.	.	.	.	.	.
<i>Odostomia chordata</i>	.	d	d	.	.	.	.	.	.
<i>Odostomia incidata</i>	.	d	d	d	.	.	.	d	d
<i>Odostomia pudica</i>	x	.	.	.	.	.	.	.	.
<i>Odostomia vestalis</i>	.	.	d	.	.	.	.	.	.
<i>Odostomia sp.</i>	.	.	.	d	.	.	.	.	.
<i>Onchidella nigricans</i>	A	.	.	.	.	.	.	.	.
<i>Onoba candidissima</i>	x	.	.	.	.	.	.	.	.
<i>Ophicardelus costellaris</i>	d	d	d	.	.	.	.	.	.
<i>Orbitestella parva</i>	a	.	.	.	.	.	.	.	.
<i>Orbitestella toreuma</i>	d	d	.	.	.	.	.	.	.
<i>Paratrophon quoyi</i>	a	.	.	.	.	.	.	.	.
<i>Patelloida corticata</i>	a	.	.	d	.	.	.	d	.
<i>Paxula paxillus</i>	x	.	.	.	.	.	.	.	.
<i>Peculator hedleyi</i>	.	a	d	d	.	.	.	d	.
<i>Penion cuverianus</i>	.	.	(d)	.	.	.	.	.	.
<i>Penion sulcatus</i>	.	d	d	d	a	.	.	.	.
<i>Pervicacia tristis</i>	a	A	a	a	.	d	.	.	.
<i>Phenacovolva wakayamaensis</i>	.	.	(a)	.	.	.	.	.	.
<i>Phenatoma rosea</i>	.	.	a	a	d	d	.	.	.
<i>Phenatoma zealandica</i>	.	.	.	a	d	.	.	.	.
<i>Phidiana milleri</i>	a	.	.	.	.	.	.	.	.
<i>Philine auriformis</i>	.	D	D	d	D	d	d	.	d
<i>Philine powelli</i>	.	.	.	.	.	.	.	d	d
<i>Philine sp.</i>	.	a	a	a	a	a	.	a	.
<i>Philinopsis taronga</i>	.	a	a	a	a	.	.	.	.
<i>Philippia lutea</i>	d	.	.	.	.	.	.	.	.
<i>Phyllocoma speciosa virginalis</i>	.	.	d	.	.	.	.	.	.
<i>Pisinna olivacea impressa</i>	.	d	d	d	.	.	.	.	.
<i>Pisinna manawatawhia</i>	.	d	d	d	.	.	.	.	.
<i>Pisinna rekohuana lactoerubra</i>	.	.	.	.	a	.	.	.	.
<i>Pisinna rekohuana rekohuana</i>	.	d	d	.	.	.	.	.	.
<i>Pisinna semiplicata</i>	.	d	d	.	.	.	.	.	.





Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
<i>Sinezona levigata</i>	.	(a)	.	.	.	.	.	.	.
<i>Sinuginella larochei</i>	.	d	d	d	.	.	.	d	.
<i>Sinuginella pygmaea</i>	d	A	A	D	d	d	a	D	d
<i>Sinuginella tryphenensis</i>	.	a	d	d	.	.	.	D	D
<i>Siphonaria australis</i>	A	d	d	.	d	d	.	.	.
<i>Spectamen plicatulum</i>	.	.	d	.	.	.	.	d	D
<i>Spectamen tryphenense</i>	.	.	.	.	.	.	d	.	.
<i>Spectamen verum</i>	.	.	.	.	.	.	.	.	d
<i>Splendrillia aoteana</i>	.	a	a	.	d	.	.	d	.
<i>Splendrillia</i> sp.	d	d	.	d	d	d	.	.	.
<i>Stephopoma rosea</i>	.	d	d	.	.	.	.	.	.
<i>Struthiolaria papulosa</i>	d	d	D	a	a	d	d	a	d
<i>Struthiolaria vermis</i>	d	D	a	A	a	D	.	.	.
<i>Syrnola crawfordi</i>	d	.	.	.	.	.	.	.	.
<i>Syrnola lurida</i>	.	.	d	d	.	d	.	.	.
<i>Syrnola menda</i>	.	.	.	.	.	.	.	a	d
<i>Tanea zelandica</i>	d	a	a	a	d	a	.	d	.
<i>Taranis</i> aff. <i>nexilis bicarinata</i>	.	.	.	.	.	.	.	a	d
<i>Taron dubius</i>	a	d	d	a	.	.	.	.	.
<i>Tenagodus weldii</i>	.	.	d	.	.	.	.	.	.
<i>Terebra circumcincta</i>	.	(a)	.	.	.	.	.	.	.
<i>Terelimella larochei</i>	.	d	.	.	.	.	.	.	.
<i>Thoristella carmesina</i>	d	d	D	d	.	d	a	.	.
<i>Thoristella oppressa</i>	.	d	.	.	.	.	a	.	.
<i>Tomopleura albula</i>	.	A	a	a	a	.	d	d	d
<i>Tonna cerevisina</i>	d	d	.	.	.	.	.	d	d
<i>Trichosirius inornatus</i>	d	d	a	d	.	d	.	d	.
<i>Tritonia incerta</i>	.	.	(a)	.	.	.	.	.	.
<i>Trivia merces</i>	d	d	a	.	.	d	.	.	.
<i>Trochus tiaratus</i>	a	A	a	a	a	d	.	d	.
<i>Trochus viridus</i>	d	d	d	d	.	.	.	d	.
<i>Tubbreva exigua</i>	x	.	.	.	.	.	.	.	.
<i>Tubbreva minutula</i>	.	d	d	d	.	.	.	.	.
<i>Tugali elegans</i>	a	d	.	d	.	d	.	.	.
<i>Tugali suteri</i>	d	d	d	d	d	d	d	d	.
<i>Turbo smaragdus</i>	A	a	d	.	.	.	d	.	d
<i>Tutufa bufo</i>	.	d	.	.	(a)	.	.	.	.
<i>Uberella barrierensis</i>	.	.	d	.	.	.	.	d	d
<i>Uberella vitrea</i>	.	.	.	.	.	.	.	.	d
<i>Umbraculum umbraculum</i>	d	.	.	.	.	.	.	.	a
<i>Veprecula cooperi</i>	.	.	.	.	.	.	.	.	d
<i>Volutomitria obscura</i>	.	.	(a)	.	.	.	.	.	.
<i>Volvarinella amoena</i>	.	.	.	.	.	.	.	d	d
<i>Volvarinella cairoma</i>	a	d	d	d	.	.	.	.	d
<i>Volvarinella subfusula</i>	.	.	.	.	.	.	.	.	D
<i>Williamia radiata nutata</i>	.	.	d	.	.	.	.	.	.
<i>Xenophora neozelanica</i>	x	.	.	.	.	.	.	.	.
<i>Xymene ambiguus</i>	d	D	D	d	d	d	.	d	.
<i>Xymene huttoni</i>	.	.	.	d	a	.	.	.	.
<i>Xymene plebeius</i>	A	A	D	a	D	a	d	.	.
<i>Xymene pusillus</i>	.	a	d	d	d	d	.	.	.



Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
<i>Xymene traversi</i>	d	d	a	d	.	.	.	.	.
<i>Zachys sarissa</i>	.	.	d	.	.	.	.	.	.
<i>Zalipais lissa</i>	x	.	.	.	.	.	.	.	.
<i>Zeacolpus pagoda</i>	d	A	A	A	D	A	A	D	d
<i>Zeacolpus vittatus</i>	.	d	d	a	D	a	.	a	.
<i>Zeacumantus lutulentus</i>	a	d	.	.	.	.	.	.	.
<i>Zeacumantus subcarinatus</i>	A	D	d	.	.	.	.	.	.
<i>Zebittium exile</i>	d	D	a	d	d	.	.	.	d
<i>Zegalerus tenuis</i>	d	A	A	A	D	A	D	D	D
<i>Zelippistes benhami</i>	.	d	d	.	.	.	d	.	.
<i>Zemitrella attenuata</i>	.	.	.	d	.	.	.	.	.
<i>Zemitrella choava</i>	.	d	d	.	.	.	.	.	.
<i>Zemitrella daemona</i>	.	.	.	.	.	.	a	.	.
<i>Zemitrella fallax</i>	.	d	.	.	.	.	.	d	.
<i>Zemitrella pseudomarginata</i>	.	.	.	.	.	.	a	.	.
<i>Zemitrella cf. sericea</i>	.	.	.	.	.	.	.	d	.
<i>Zemitrella turgida</i>	x	.	.	.	.	.	.	.	.
<i>Zeradina odhneri</i>	.	.	.	.	.	.	.	.	d
<i>Zeradina ovata</i>	.	.	.	.	.	.	.	.	d
<i>Zeradina producta</i>	.	.	.	.	.	.	.	.	d
<i>Zerotula ammonitoides</i>	.	d	.	d	.	.	.	.	.
BIVALVIA									
<i>Acar sandersonae</i>	d	.	d	.	.	.	d	d	.
<i>Acar sociella</i>	.	d	d	d	.	d	d	.	D
<i>Anisodonta alata alata</i>	.	.	.	d	d	d	.	d	d
<i>Anomia trigonopsis</i>	d	D	d	D	d	.	.	.	.
<i>Arthritica bifurca</i>	.	A	a	A	.	.	.	a	.
<i>Atrina zelandica</i>	d	A	a	D	a	d	A	A	d
<i>Austroneaera finlayi</i>	.	d	.	.	.	.	.	.	d
<i>Austrovenus stutchburyi</i>	A	D	d	.	D	.	.	.	.
<i>Bankia</i> sp.	d	.	.	.	.	.	.	.	.
<i>Barbatia novaezelandiae</i>	a	a	d	d	d	.	d	d	d
<i>Barnea similis</i>	d	d	.	.	.	.	.	.	.
<i>Bassina yatei</i>	d	d	a	a	.	.	.	.	.
<i>Benthocardiella obliquata</i>	.	d	.	.	.	.	.	.	.
<i>Borniola reniformis</i>	.	d	a	.	.	.	a	d	d
<i>Cardita aoteana</i>	d	d	d	d	.	.	.	d	d
<i>Cardita brookesi</i>	a	.	.	d	.	.	d	d	.
<i>Carditella delli</i>	.	.	.	.	.	.	.	.	d
<i>Chlamys gemmulata</i>	.	.	d	.	.	.	d	.	.
<i>Chlamys zelandiae</i>	d	A	a	D	D	D	D	D	D
<i>Condylocardia crassicosta</i>	.	d	d	.	.	.	.	.	.
<i>Condylocuna concentrica</i>	.	d	d	.	.	.	.	.	.
<i>Corbula zelandica</i>	A	A	A	A	A	A	D	A	d
<i>Cosa serratocostata</i>	.	d	d	d	.	.	.	d	.
<i>Crassostrea gigas</i>	A	d	d	d	.	.	.	.	.
<i>Crenella radians</i>	.	.	.	.	.	.	.	d	d
<i>Cuspidaria trailli</i>	.	.	.	.	.	D	.	A	A
<i>Cuspidaria wellmani</i>	.	.	.	.	.	.	.	.	d
<i>Cyclomactra ovata</i>	d	A	.	.	.	.	.	.	.
<i>Cyclopecten mestayerae</i>	.	.	d	.	.	.	.	.	.

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
<i>Cyclopecten</i> sp.	.	d	.	.	.	.	.	.	.
<i>Diplodonta globus</i>	.	.	.	d	.	.	.	d	d
<i>Diplodonta striatula</i>	d	a	.	.	.	.	.	.	.
<i>Divaricella huttoniana</i>	d	D	d	a	d	d	d	a	D
<i>Divarilima sydneyensis</i>	d	d	d	d	.	d	.	.	.
<i>Dosina zelandica</i>	d	A	A	D	D	d	d	d	d
<i>Dosinia anus</i>	d	.	.	.	.	.	.	.	.
<i>Dosinia greyi</i>	.	a	a	A	a	.	.	a	.
<i>Dosinia lambata</i>	d	A	A	A	A	d	a	a	.
<i>Dosinia maoriana</i>	d	a	A	a	A	d	d	a	.
<i>Dosinia subrosea</i>	d	A	A	a	.	.	.	.	.
<i>Elliptotellina urinatoria</i>	.	.	d	.	.	.	.	.	.
<i>Felaniella zelandica</i>	A	A	A	A	D	A	A	d	d
<i>Gari convexa</i>	d	A	a	.	.	.	.	.	.
<i>Gari lineolata</i>	d	A	A	A	a	a	D	d	.
<i>Gari stangeri</i>	d	A	A	A	d	d	D	d	.
<i>Glycymeris modesta</i>	d	A	A	A	D	D	A	D	.
<i>Gonimyrtia concinna</i>	.	a	a	.	.	d	.	a	d
<i>Haliris setosa</i>	.	.	.	.	.	.	.	.	d
<i>Hamacuna aupouria</i>	.	.	d	d	.	.	.	.	.
<i>Hiatella arctica</i>	d	d	a	d	d	d	d	d	d
<i>Hunkydora australica</i>									
<i>novozelandica</i>	d	A	A	A	A	a	d	a	d
<i>Irus reflexus</i>	d	d	.	.	.	.	.	.	.
<i>Kidderia costata</i>	.	(a)	.	.	.	.	.	.	.
<i>Lasaea hinemoa</i>	a	.	d	.	.	.	.	.	.
<i>Lasaea maoria</i>	a	.	.	.	.	.	.	.	.
<i>Leionucula strangei</i>	.	.	a	.	A	a	D	A	.
<i>Leptomya retiaria</i>	a	A	A	A	A	D	d	d	.
<i>Limaria orientalis</i>	a	A	A	a	.	d	.	.	.
<i>Limatula maoria</i>	d	A	a	a	d	D	d	d	D
<i>Macomona liliana</i>	A	A	a	d	d	.	.	.	.
<i>Mactra murchisoni</i>	d	.	.	.	.	.	.	.	.
<i>Maorimactra ordinaria</i>	d	a	a	d	.	d	D	.	.
<i>Melliteryx parva</i>	.	A	d	A	.	.	.	.	d
<i>Mesopeplum convexum</i>	.	d	.	.	.	d	d	D	.
<i>Modiolarca impacta</i>	a	d	.	d	D	d	d	d	.
<i>Modiolus areolatus</i>	d	d	a	d	.	d	.	.	.
<i>Moerella huttoni</i>	.	a	a	A	d	.	A	d	.
<i>Montacuta semiradiata</i>	.	.	a	a	a	.	.	.	.
<i>Musculista senhousia</i>	a	A	.	.	.	.	.	.	.
<i>Myadora antipodum</i>	.	a	a	a	.	A	d	a	d
<i>Myadora boltoni</i>	.	a	a	d	.	.	.	.	.
<i>Myadora novaezelandiae</i>	.	.	.	a	.	A	.	.	d
<i>Myadora striata</i>	d	A	A	A	a	d	D	d	.
<i>Myadora subrostrata</i>	.	d	d	a	D	d	d	d	.
<i>Myllita stoweii</i>	.	d	d	d	d	d	.	d	.
<i>Myllitella vivens</i>	.	d	d	.	.	.	.	.	.
<i>Myochama tasmanica</i>	.	.	.	.	.	.	.	d	d
<i>Mysella ?alpha</i>	.	.	d	.	.	.	.	.	.
<i>Mysella aupouria</i>	.	.	.	d	.	.	.	.	.



Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
<i>Mysella larochei</i>	.	.	.	.	.	.	.	d	d
<i>Mysella tellinula</i>	.	.	d	.	.	.	.	.	.
<i>Mytilus edulis galloprovincialis</i>	.	d	.	.	.	.	d	D	.
<i>Neilo australis</i>	.	.	.	a	D	d	d	A	D
<i>Neolepton antipodum</i>	.	.	d	d	.	.	.	.	d
<i>Notocallista multistriata</i>	a	A	d	A	A	a	A	A	a
<i>Nucinella maoriana</i>	.	.	.	.	.	.	.	.	d
<i>Nucula certisinus</i>	.	.	.	.	.	.	.	.	d
<i>Nucula hartvigiana</i>	A	A	A	d	A	d	.	.	.
<i>Nucula nitidula</i>	a	A	A	A	A	A	A	D	d
<i>Ostrea chilensis</i>	d	D	d	D	D	.	.	d	.
<i>Oxyperas elongata</i>	.	d	d	a	.	.	d	.	.
<i>Panopea zelandica</i>	d	.	.	.	.	.	.	.	.
<i>Paphies australis</i>	a	a	d	.	d	.	.	.	.
<i>Paphies subtriangulata</i>	d	d	.	.	.	.	.	.	.
<i>Parvithracia suteri</i>	x	.	.	.	.	.	.	.	.
<i>Pecten novaezealandiae</i>	d	A	a	D	a	d	D	a	d
<i>Periploma angasi</i>	.	.	d	.	.	.	.	.	.
<i>Perna canaliculus</i>	a	a	.	.	.	.	.	.	.
<i>Peronaea gaimardi</i>	d	.	.	.	.	.	.	.	.
<i>Philobrya acutangulata</i>	.	d	d	d	.	.	.	.	d
<i>Philobrya</i> aff. <i>acutangula</i>	.	.	a	.	.	.	.	.	.
<i>Philobrya</i> cf. <i>modiolus</i>	.	.	d	.	.	.	.	.	.
<i>Philobrya munita</i>	.	a	.	.	.	.	d	.	.
<i>Philobrya</i> aff. <i>pinctada</i>	.	.	d	.	.	.	.	.	.
<i>Pleuromeris latiuscula</i>	.	a	.	a	.	.	.	.	.
<i>Pleuromeris paucicostata</i>	.	d	a	a	.	d	a	D	d
<i>Pleuromeris zelandica</i>	a	A	A	A	A	A	A	D	D
<i>Pleuromeris</i> sp.	.	.	d	.	.	.	.	.	.
<i>Pododesmus zelandicus</i>	.	.	.	.	.	.	.	.	d
<i>Poroleda lanceolata</i>	.	.	.	.	.	.	.	d	d
<i>Pratulum pulchellum</i>	d	D	d	A	A	a	A	A	A
<i>Protothaca crassicosta</i>	d	.	.	.	.	.	.	.	.
<i>Pseudoarcomegma disculus</i>	d	d	a	d	.	.	.	.	.
<i>Ruditapes largillierti</i>	a	A	A	d	d	.	.	d	.
<i>Saccella bellula</i>	.	.	d	.	d	d	A	A	A
<i>Saccostrea cucullata</i>	A	d	.	.	.	.	.	d	.
<i>Scalpomactra scalpellum</i>	.	A	D	A	a	A	A	D	d
<i>Scintilla stvensoni</i>	d	.	.	.	.	.	.	.	.
<i>Scintillona zelandica</i>	.	a	d	a	.	.	.	.	.
<i>Serratina charlottae</i>	.	.	.	a	a	d	a	a	A
<i>Solemya parkinsoni</i>	.	a	.	.	.	.	.	a	.
<i>Soletellina nitida</i>	d	a	.	d	.	.	.	.	.
<i>Talabrica bellula</i>	.	A	a	.	.	.	d	a	.
<i>Tawera spissa</i>	d	A	A	A	A	A	A	D	d
<i>Tellinota edgari</i>	d	A	A	A	A	.	.	.	.
<i>Theora lubrica</i>	a	A	A	A	A	D	A	d	d
<i>Thracia vegrandis</i>	.	.	.	.	.	.	d	.	.
<i>Trichomusculus barbatus</i>	.	d	a	d	.	.	D	.	.
<i>Tucetona laticostata</i>	d	A	A	a	d	A	d	D	.
<i>Varinucula gallinacea</i>	.	a	d	a	.	.	.	.	d

Depth (metres)	tidal	1-5	6-10	11-15	16-20	21-25	26-30	31-40	41-60
<i>Venericardia purpurata</i>	d	A	A	A	A	D	A	A	D
<i>Volupicuna compressidens</i>	.	.	.	.	.	.	a	.	d
<i>Volupicuna manawatawhia</i>	.	.	.	.	.	.	.	.	d
<i>Volupicuna mayi</i>	.	.	.	a	.	.	.	.	.
<i>Volupicuna waikukuensis</i>	x	.	.	.	.	.	.	.	.
<i>Xenostrobus pulex</i>	A	d	.	d	d	.	.	.	.
<i>Xenostrobus securis</i>	.	d	.	.	.	.	.	.	.
<i>Zelithophaga truncata</i>	d	d	.	.	.	.	.	.	.
<i>Zenatia acinaces</i>	a	A	a	A	A	d	d	A	.
SCAPHOPODA									
<i>Antalis nana</i>	.	.	.	.	a	.	.	a	d
<i>Cadulus teliger</i>	.	.	.	.	.	d	d	d	d
CEPHALOPODA									
<i>Spirula spirula</i>	d	.	.	.	.	.	.	.	.
BARNACLES									
<i>Balanus decorus</i>	.	d	.	.	d	.	.	.	.
<i>Balanus trigonus</i>	d	A	d	d	d	.	.	.	.
<i>Balanus vestitutus</i>	.	d	d	d	d	.	D	D	.
<i>Chamaesipho brunnea</i>	A	d	.	.	.	.	.	.	.
<i>Chamaesipho columna</i>	A	d	.	.	.	.	.	.	.
<i>Elminius modestus</i>	A	d	.	.	.	.	.	.	.
<i>Epopella plicata</i>	A	d	.	.	.	.	.	.	.
BRYOZOA									
<i>Otionella</i> sp.	.	d	.	.	.	.	A	A	d
ECHINOIDS									
<i>Apatopygus recens</i>	.	.	a	.	.	a	.	.	.
<i>Brissus gigas</i>	.	.	(a)	.	.	.	.	.	.
<i>Centrostephanus rodgersii</i>	.	(a)	.	.	.	.	.	.	.
<i>Clypeaster australasiae</i>	.	.	.	.	(a)	.	.	.	.
<i>Echinocardium cordatum</i>	d	A	A	A	A	a	d	A	.
<i>Evechinus chloroticus</i>	A	a	d	d	d	d	d	d	.
<i>Fellaster zelandiae</i>	d	d	d	.	.	.	.	.	.
<i>Holopneustes inflatus</i>	a	(a)	.	.	.	.	.	.	.
<i>Peronella hinemoa</i>	.	.	.	.	.	.	.	.	d
<i>Pseudoboleta indiana</i>	.	.	.	.	(a)	.	.	.	.
<i>Tripneustes gratilla</i>	.	(a)	.	.	.	.	.	.	.
CORALS									
<i>Caryophyllia</i> sp.	.	.	.	.	.	.	.	.	d
<i>Culicia rubeola</i>	.	A	d	a	d	d	D	d	d
<i>Hoplansia duotrix</i>	x	.	.	.	.	.	.	.	.
<i>Kionotrochus suteri</i>	.	.	.	.	.	.	d	d	D
<i>Monomyces rubrum</i>	a	.	d	d	d	A	D	A	d
<i>Sphenotrochus ralphae</i>	.	.	d	.	.	.	a	d	.
<i>Tethocyathus cylindraceus</i>	.	.	.	.	.	.	.	.	d
BRACHIOPODS									
<i>Calloria inconspicua</i>	d	.	a	a	.	d	a	a	.
<i>Calloria variegata</i>	.	.	.	d	.	.	.	.	.
<i>Terebratella haurakiensis</i>	.	.	.	.	.	.	.	d	.
RHODOLITH ALGAE	d	A	A	A	d	D	D	.	.